Appendix L. South Fork Clearwater River Subbasin Sediment Budget

Table of Contents

List of Tables

List of Figures

Appendix L. South Fork Clearwater River Subbasin Sediment Budget

This document establishes the record of the sediment budget developed for sources of sediment in the South Fork Clearwater River (SF CWR) Subbasin Assessment and Total Maximum Daily Loads (TMDL). The methods used to establish the sediment budget consisted of identifying the major sources of sediment in the subbasin, identifying methods of quantifying that sediment on a yearly basis, planning and implementing projects to collect missing data, organizing all of the data in a geographical information systems (GIS) format so they could be compared and analyzed, and using the results as the basis for the sediment loading calculations presented in Chapter 5.

The major sources of sediment identified in the subbasin are forestry, agriculture, grazing, mining, roads, mass failures, and in-stream erosion.

The SF CWR Subbasin has two distinct areas of management; and therefore, different types of sets of data about human caused sediment. The eastern two-thirds of the subbasin is dominantly managed by the Nez Perce National Forest (NPNF) and the Bureau of Land Management (BLM) and has data sets consistent with federally managed lands. The lower one-third of the subbasin is largely private land dominated by agriculture and grazing, with different types of sediment data available. The task was to consider the types of data, figure out how to fill in the gaps, and make it all fit together in a reasonable manner consistent with the narrative water quality sediment standard.

In the final analysis, we put together the patchwork of data shown in Table L-1, which quantifies all the major sources of sediment in the SF CWR Subbasin.

The results of the NPNF Sediment Model (NEZSED) and the Revised Universal Soil Loss Equation (RUSLE) models were already available at the outset of the project. Significant to our analysis of the area of federally-managed lands; however, NEZSED does not include estimates of human activity-induced mass failures, estimates of in-stream erosion, estimates of road gravel loading from the highway, nor the general effects of mining or grazing.

The NPNF also already had an inventory of mass failures for the upper two-thirds of the subbasin. We extrapolated those results, along with data from the Cottonwood Creek TMDL (DEQ, NPT, USEPA 2000) and an aerial photo interpretation, to arrive at an estimate of mass failures in the non-inventoried part of the basin

We concluded that the sediment producing effects of grazing and mining could largely be quantified if we inventoried stream bank erosion. With funds made available by U.S. Environmental Protection Agency (USEPA), we hired an inventory crew that inventoried all of the significantly eroding stream banks in the subbasin, except for the Cottonwood Creek watershed. This resulted in a uniform data set across all the lands with respect to in-stream erosion.

Table L-1. Data sources for the SF CWR subbasin sediment budget.

Data Type*	Sediment Source
NEZSED Model	Fire Erosion
NEZSED Model	Road Erosion
NEZSED Model	Logging Erosion
NEZSED Model	Natural Erosion
NRCS Stream Erosion Inventory	Forest and Mining In-Stream Erosion
NRCS Stream Erosion Inventory	Agriculture and Grazing In-Stream Erosion
NPNF/BLM Mass Failure Inventory	Mass Failures
Mass Failure Extrapolation	Agriculture and Grazing Mass Failures
WEPP Roads Model	Non-Federal Roads
RUSLE Model	Agriculture and Grazing Land Erosion
ITD Gravel Estimate	Highway Gravel Use
Mining Glory Hole Sediment Estimate	Eroding Walls

*NEZSED = Nez Perce National Forest Sediment Model, NRCS = Natural Resources Conservation Service, NPNF = Nez Perce National Forest, BLM = Bureau of Land Management, WEPP = Watershed Erosion Prediction Project, RUSLE = Revised Universal Soil Loss Equation, ITD = Idaho Transportation Department

Also with funds made available by USEPA, we funded a project through the University of Idaho to develop a geographic position system (GPS)/GIS interface for the Watershed Erosion Prediction Project (WEPP) road model. This allowed us to rapidly collect the data to run the model using GPS, transfer it to the GIS, and load it into the model. This provided the data set for the non-federal roads, except for the main highway along the river from Kooskia to Elk City. It had been observed that large portions of the gravel used to maintain safe driving conditions in the winter were ending up in the river. We got an estimate from the Idaho Transportation Department (ITD) of the amount of gravel being applied to the road each year.

Each sediment source, its appropriate data set or model, the calculation results, and the implications to the sediment loading calculations are discussed below.

Forest Practices (NEZSED Model)

Most of the federally managed land is forested. The main data set from the federally managed lands was derived from the NEZSED model. The NEZSED model is a computerized sediment delivery prediction model developed by the NPNF based on guidelines developed by hydrologists and soil scientists from the U.S. Forest Service (USFS) Northern and Intermountain Regions (USFS 1981). We used portions of the data set developed for the South Fork Clearwater Landscape Assessment (USFS 1998). The sediment yield was modeled for the period 1870 through 2000 and includes the effects of fire, timber harvest, and roads. It includes natural baseline data and results in a reasonable estimate of background loads. The model predicts sediment yield recovery to background rates within five and seven years for burned areas and logged areas, respectively. The model predicts continuing sediment production from roads so long as they remain on the landscape.

The NEZSED sediment delivery model, along with the whole family of models using the R1/R4 (USFS 1981) methods, has been subject to considerable scrutiny and has been found to underpredict more often than it overpredicts. In a fairly intensive research project on the NPNF, Gloss (1994) found that the model underpredicted actual sediment yield on the order of 50%. We do not attempt to correct any of the predictions in our use of the NEZSED data; however, the idea that sediment yield from the upper part of the basin may be greater than predicted lends weight to our final recommendations that sediment loads from the federally-managed parts of the subbasin need to be reduced to fully restore the beneficial uses. Further, since sediment-loading reductions are presented as percentages measured by NEZSED, any under prediction would be compensated for.

On the other hand, considering the NEZSED model results in relation to the subbasin as a whole, the magnitude of human activity-caused sediment from agricultural and grazing practices in the subbasin far outweighs the amount of sediment coming from forestry. If one is going to be concerned about error levels of the estimates, total human-caused sediment from forestry is probably less than the error in estimates of eroded sediment from agricultural and grazing lands in the subbasin.

The NEZSED data were received from the NPNF by sixth order HUC as defined by the forest. We reallocated those results to the water bodies defined in IDAPA 58.01.02.120.07, based primarily on the number of miles of roads by area, since the majority of NEZSED sediment is produced from roads. Table L-2 shows the breakdown of sediment yield for each of the water bodies in the federally managed portion of the subbasin. Generally, Table L-2 shows total sediment yield, then subtracts out the background sediment, resulting in an estimate of human-caused sediment.

This human-caused sediment is then routed through the hydrologic network based on the Roehl (1962) equation, resulting in the final estimate of human-caused sediment in the water that must be addressed in this TMDL. The Roehl (1962) equation produces a routing coefficient that is applied to all of the sediment sources identified in the SF CWR Subbasin. The routing equation simply identifies a relationship between size of the drainage and the percent of eroded material that moves out of the drainage (Routing Coefficient = drainage area in square miles raised to the negative 0.18 power [$RC = A^{(-0.18)}$]. The larger the drainage, the smaller the routing coefficient, indicating that more of the material is being stored inside the watershed. Figure L-1 displays the magnitude of forest practice-caused sediment from the various water bodies in the subbasin.

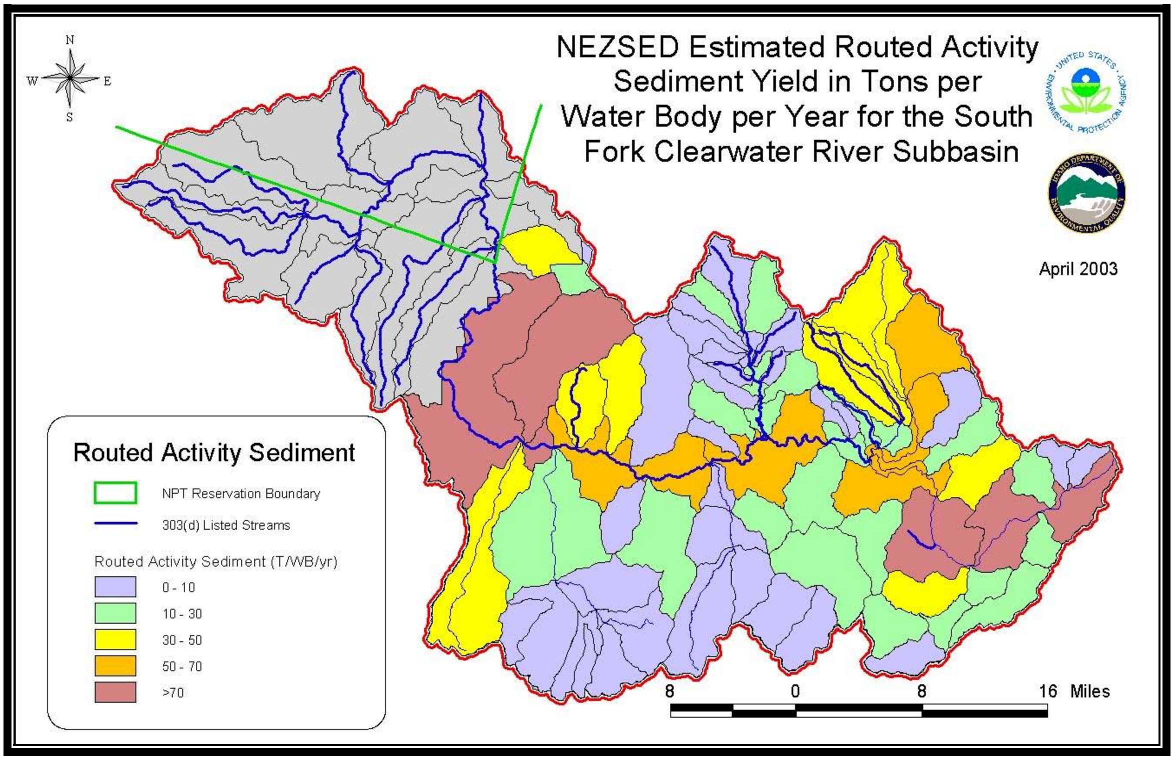

Figure L-1. NEZSED Estimated Human-Caused Sediment Yield per Year

The interesting results from these data are the totals and the few water bodies that are delivering 50 tons/year or greater to the system. The major contributors of human-caused sediment are the main stem water bodies; lower, middle, and upper Red River; lower American River; East Fork American River; and Meadow Creek. Cougar Creek and Buffalo Gulch produce slightly less sediment than these other water bodies. Total modeled human-caused sediment is only about 10% of background.

Table L-2. NEZSED model sediment estimates for the SF CWR Subbasin.

Water Body Name	Water Body No.	Area	Total	Back-ground Rate	Total Back-ground	Human Caused Rate	Rate From Roads	Total Human Caused	Routing Coeffic-ient	Total Routed	Total Human Caused Routed
		(mi^2)	(t/WB/yr)	($t/mi^2/yr$)	(t/WB/yr)	($t/mi^2/yr$)	(t/mi/yr)	(t/WB/yr)		(t/WB/yr)	(t/WB/yr)
Mid-L. SF CWR	12	60.98	2,650.54	38.22	2,502.85	2.26	0.50	147.69	0.55	1,457.80	81.23
Mill	13	36.58	1,050.29	26.77	971.08	2.18	0.74	79.21	0.52	549.45	41.44
L. Johns	14	41.22	1,247.94	29.40	1,211.61	0.88	0.47	36.34	0.51	638.97	18.60
Gospel	15	16.92	1,207.07	71.68	1,207.05	0.00	0.00	0.03	0.60	725.44	0.02
WF Gospel	16	6.98	345.93	49.80	345.59	0.05	0.11	0.34	0.70	243.83	0.24
Mid Johns	17	15.94	510.02	31.95	508.97	0.07	0.11	1.06	0.61	309.85	0.64
U. Johns	18	13.55	543.73	40.16	543.73	0.00	0.00	0.00	0.63	340.11	0.00
Moores	19	6.23	550.76	88.81	550.64	0.02	0.01	0.12	0.72	396.24	0.09
Sq. Mountain	20	3.58	316.43	88.86	316.36	0.02	0.05	0.07	0.80	251.57	0.06
Hagen	21	8.65	416.83	48.47	416.83	0.00	0.00	0.00	0.68	282.67	0.00
M. SF CWR	22	29.61	1,167.08	36.24	1,072.65	3.19	1.19	94.43	0.54	634.21	51.31
Wing	23	8.33	256.28	30.16	251.20	0.61	0.36	5.08	0.68	175.00	3.47
Twentymile	24	22.88	476.47	20.04	458.20	0.80	0.51	18.27	0.57	271.24	10.40
L. Tenmile	25	3.82	119.74	30.06	114.81	1.29	2.09	4.93	0.79	94.06	3.87
M. Tenmile	26	11.29	313.35	26.85	303.10	0.91	0.58	10.25	0.65	202.55	6.63
U. Tenmile	27	21.28	998.22	47.09	998.21	0.00	0.00	0.01	0.58	575.71	0.01
Williams	28	9.20	262.21	28.53	262.19	0.00	0.01	0.02	0.67	175.84	0.01
Sixmile	29	8.02	151.53	16.84	135.04	2.06	1.06	16.49	0.69	104.18	11.34

Water Body Name	Water Body No.	Area	Total	Back-ground Rate	Total Back-ground	Human Caused Rate	Rate From Roads	Total Human Caused	Routing Coeffic-ient	Total Routed	Total Human Caused Routed
		(mi^2)	(t/WB/yr)	(t/mi^2/yr)	(t/WB/yr)	(t/mi^2/yr)	(t/mi/yr)	(t/WB/yr)		(t/WB/yr)	(t/WB/yr)
Mid-U. SF CWR	30	26.82	847.55	28.03	751.79	3.57	1.03	95.77	0.55	468.86	52.98
L. Crooked	31	14.81	417.69	25.07	370.98	3.16	1.00	46.72	0.62	257.12	28.76
U. Crooked	32	22.64	460.01	18.82	425.24	1.54	0.75	34.77	0.57	262.36	19.83
WF Crooked	33	11.87	269.93	22.62	266.51	0.29	0.30	3.42	0.64	172.93	2.19
EF Crooked	34	10.45	286.97	27.08	280.26	0.65	0.98	6.71	0.66	188.10	4.40
Relief	35	11.69	226.15	16.73	195.80	2.59	0.70	30.36	0.64	145.27	19.50
U. SF CWR	36	4.21	147.47	25.90	109.31	9.04	3.12	38.15	0.77	113.84	29.45
L. Red	37	16.15	375.79	17.41	281.17	5.86	1.01	94.62	0.61	227.77	57.35
M. Red	38	25.07	680.29	20.06	502.62	7.09	1.37	177.67	0.56	380.95	99.49
Moose Butte	39	11.07	261.49	17.24	191.91	6.29	1.22	69.58	0.65	169.62	45.14
L. SF Red	40	4.93	111.80	17.93	88.23	4.79	1.15	23.57	0.75	83.90	17.69
M. SF Red	41	4.36	107.84	18.88	82.13	5.91	1.37	25.72	0.77	82.73	19.73
WF Red	42	10.01	185.86	17.06	170.06	1.58	0.67	15.79	0.66	122.77	10.43
U. SF Red	43	7.41	135.89	17.10	124.16	1.62	0.44	11.73	0.70	94.75	8.18
Trapper	44	11.06	215.15	17.56	193.15	2.00	0.65	21.99	0.65	139.60	14.27
U. Red	45	30.08	744.99	19.74	592.77	5.07	1.34	152.23	0.54	403.71	82.49
Soda	46	5.24	115.14	18.11	94.53	3.95	1.08	20.62	0.74	85.46	15.30
Bridge	47	3.72	89.97	21.49	79.93	2.70	1.38	10.04	0.79	71.03	7.93

Water Body Name	Water Body No.	Area	Total	Back-ground Rate	Total Back-ground	Human Caused Rate	Rate From Roads	Total Human Caused	Routing Coeffic-ient	Total Routed	Total Human Caused Routed
		(mi^2)	(t/WB/yr)	($t/mi^2/yr$)	(t/WB/yr)	($t/mi^2/yr$)	(t/mi/yr)	(t/WB/yr)		(t/WB/yr)	(t/WB/yr)
Otterson	48	3.89	81.15	20.78	80.85	0.08	0.10	0.30	0.78	63.55	0.23
Trail	49	7.13	160.17	19.89	141.60	2.61	1.11	18.57	0.70	112.48	13.04
Siegel	50	12.16	266.48	17.74	215.88	4.16	1.15	50.60	0.64	169.96	32.27
Red Horse	51	9.07	216.56	21.19	191.96	2.72	1.13	24.61	0.67	145.61	16.54
L. American	52	11.27	281.16	17.38	195.69	7.59	2.25	85.47	0.65	181.80	55.27
Kirks Fork	53	9.78	235.13	22.95	224.70	1.06	0.62	10.43	0.66	155.98	6.92
EF American	54	17.88	413.33	18.44	328.64	4.75	1.60	84.68	0.60	245.96	50.39
U. American	55	23.87	621.65	23.54	559.81	2.60	1.01	61.85	0.56	351.19	34.94
Elk	56	3.63	128.09	28.96	105.13	6.33	2.29	22.96	0.79	101.56	18.20
Little Elk	57	7.94	190.05	18.15	143.91	5.82	1.72	46.14	0.69	130.89	31.77
Big Elk	58	13.78	416.10	24.45	337.22	5.72	1.95	78.87	0.62	259.49	49.19
Buffalo	59	3.34	86.48	20.70	69.15	5.19	1.19	17.32	0.80	69.59	13.94
Whiskey	60	2.59	62.36	20.54	52.98	3.63	1.05	9.38	0.84	52.53	7.90
Maurice	61	1.71	38.92	19.56	33.46	3.20	1.08	5.47	0.91	35.34	4.96
L. Newsome	62	6.48	188.94	24.24	156.82	4.96	1.04	32.12	0.71	134.98	22.95
Bear	63	5.99	143.43	19.57	117.05	4.41	0.81	26.38	0.72	103.93	19.11
Nugget	64	2.27	44.24	16.47	37.39	3.01	0.66	6.84	0.86	38.17	5.90
Beaver	65	5.83	122.06	19.18	112.01	1.72	0.67	10.05	0.73	88.86	7.32
M. Newsome	66	1.77	51.81	24.15	42.99	4.95	1.12	8.82	0.90	46.73	7.95

Water Body Name	Water Body No.	Area	Total	Back-ground Rate	Total Back-ground	Human Caused Rate	Rate From Roads	Total Human Caused	Routing Coeffic-ient	Total Routed	Total Human Caused Routed
		(mi^2)	(t/WB/yr)	($t/mi^2/yr$)	(t/WB/yr)	($t/mi^2/yr$)	(t/mi/yr)	(t/WB/yr)		(t/WB/yr)	(t/WB/yr)
Mule	67	8.59	190.11	17.69	151.61	4.49	0.87	38.50	0.68	129.09	26.14
U. Newsome	68	9.93	223.54	21.13	208.98	1.47	0.64	14.56	0.66	147.88	9.63
Haysfork	69	4.96	134.79	23.20	114.38	4.14	0.83	20.41	0.75	101.05	15.30
Baldy	70	4.26	118.57	25.21	106.88	2.76	0.59	11.69	0.77	91.36	9.01
Pilot	71	6.12	163.02	25.87	158.09	0.81	0.71	4.94	0.72	117.66	3.56
Sawmill	72	2.76	76.91	27.70	76.72	0.07	0.55	0.19	0.83	64.04	0.15
Sing Lee	73	2.43	73.04	27.12	65.90	2.94	0.69	7.14	0.85	62.25	6.08
WF Newsome	74	5.16	151.06	27.77	143.29	1.51	0.54	7.78	0.74	112.42	5.79
Leggett	75	7.80	231.19	26.29	205.04	3.35	0.75	26.15	0.69	159.73	18.07
Fall	76	3.65	107.71	26.18	95.30	3.41	1.02	12.41	0.79	85.33	9.83
Silver	77	25.81	638.58	24.18	623.03	0.60	0.40	15.55	0.56	355.71	8.66
Peasley	78	14.21	440.00	26.61	377.84	4.38	0.94	62.17	0.62	272.90	38.56
Cougar	79	12.09	342.80	23.07	278.69	5.31	1.25	64.12	0.64	218.88	40.94
Meadow	80	37.52	1,164.39	26.75	1,003.16	4.30	0.96	161.23	0.52	606.37	83.96
Sally Ann	81	4.09	128.74	27.63	113.56	3.70	0.62	15.19	0.66	85.37	10.07
Rabbit	82	0.68	12.90	17.69	12.03	1.28	0.21	0.87	0.67	8.64	0.58
	Totals	857.09	26,209.85		23,852.35			2,357.51		16,006.74	1,449.60

In-Stream Erosion

As noted above, the NEZSED model does not account for sediment coming from human-caused mass failures, impacts from grazing, or impacts from mining. (The background sedimentation rate in NEZSED does include naturally occurring mass failures.) In order to account for the impacts of grazing and mining as they affect stream stability, we collected data on in-stream erosion throughout the whole subbasin, except Cottonwood Creek. The methods followed in this data collection exercise appear as an attachment at the end of this appendix (Attachment L-1). Streams sampled and the results are shown in Table L-3.

Table L-3. In-stream sediment produced in the SF CWR Subbasin.

In-Stream Erosion Data					
Water Body No.	**Water Body Name**	**Sediment in Tons per Stream Mile**	**Sediment in Tons per Water Body**	**Routing Coeffic-ient**	**Routed Sediment**
		(t/mi/yr)	**(t/WB/yr)**		**(t/WB/yr)**
10	Threemile Creek	39	616	0.58	357
11	Butcher Creek	23	211	0.62	131
38	Middle Red River	14	210	0.56	118
39	Moose Butte Creek	17	12	0.65	8
45	Upper Red River	5	62	0.54	34
49	Trail Creek	3	3	0.70	2
50	Siegel Creek	22	15	0.64	10
55	Upper American River	3	39	0.56	22
56	Elk Creek	53	124	0.79	98
57	Little Elk Creek	2	25	0.69	17
58	Big Elk Creek	11	63	0.62	39
59	Buffalo Gulch	1	4	0.80	3
62	Lower Newsome Creek	4	36	0.71	26
75	Leggett Creek	1	1	0.69	1
80	Meadow Creek	15	53	0.52	27
81-Non FS* Land	Sally Ann Creek	1	1	0.66	1
82-Non FS Land	Rabbit Creek	1	1	0.67	1
	Total	213	1,473		891

*Non FS = not federally managed

The largest producers of in-stream sediment are Threemile Creek, Butcher Creek, Middle Red River, and Elk Creek. We note in the methods that we only sampled streams known to be actively eroding. These data show that the grand majority of sediment from in-stream erosion is coming from a few locations. The total routed in-stream erosion sediment being produced is about 60% of the total routed human-caused sediment being produced from forest activities on the federal lands. About half of that, however, is coming from Threemile and Butcher Creeks.

State Highway (Highway 14) from Kooskia to Elk City

Another major source of sediment is the state highway from Kooskia to Elk City. It is regularly graveled during the winter to improve driving conditions and much of the gravel ends up in the river.

We estimated the amount of sediment coming from the state highway based on the gravel crushed by ITD for the Reed's Bar shed. The ITD crushes approximately 10,000 tons of gravel every four years or so that is used for the portion of the road from the Mt. Idaho bridge to Elk City, a distance of 50 miles. This results in about 200 tons of gravel per mile , which over 4 years equals about 50 tons/mile/year. Of course, not all of this reaches the river, but a significant portion does. Some portion is applied to parts of the road that have some sort of a buffer to the river. We estimated that about 80% of the highway is directly adjacent to the river. Given these conditions, we used a 40 tons/mile rate for the state highway from Harpster to Elk City. We placed these estimates in the sediment budget before the routing equation was applied, so the estimates are reduced by the Roehl (1962) routing coefficient. Table L-4 shows the estimates of sediment from State Highway 14. These estimates of total sediment delivery are the same order of magnitude as those from NEZSED and the in-stream erosion survey.

Table L-4. Sediment delivered from State Highway 14 along the SF CWR.

Water Body No.	Water Body Name	Miles of Road	Tons of Sediment	Routing Coefficient	Routed Sediment
		(miles)	(t/WB/yr)		(t/WB/yr)
12	Mid-Lower SF CWR	23.7	948	0.55	521
22	Middle SF CWR	11.7	468	0.54	253
30	Mid-Upper SF CWR	11.8	472	0.55	260
36	Upper SF CWR	3.7	148	0.77	114
	Total	50.9	2,036		1,148

Mass Failures

Another major source of sediment identified from both privately and publicly managed lands is mass failures that are related to human activities. For the most part, these are mass failures associated with roads. In general, a few mass failures occur every year, but the major contributors of sediment are the major episodes of mass failure that occur during large rain-on-snow events or during other high precipitation events when the soil mantle becomes supersaturated. The last major mass failure event in the region occurred during the storms of 1996. The NPNF and BLM conducted an inventory of the mass failures that occurred during that event.

We acquired the NPNF mass failure database and identified those mass failures associated with roads. An estimate of percent delivery of sediment to the stream was not consistently included in the database. As an alternative, we applied the Roehl (1962) routing coefficient to the total sediment production to arrive at an estimate of percent delivery. This is consistent with our and NEZSED's application of the routing coefficient to all the sediment sources in the subbasin, in the absence of a better way to approach the routing question in a more site-specific or source-specific manner.

The NPNF data set documents mass failures that occurred primarily during the 1996 storms. This sediment production rate cannot be assumed to occur annually. Based on data from the last century, McClelland et al. (1997) conclude that major rain-on-snow events of the sort that cause major mass failure episodes occur on a 15 to 20 year interval. We, therefore, assumed a 15-year interval and divided the total sediment produced by the mass failures by 15 to arrive at a yearly rate. Table L-5 shows these results.

The NPNF data set only covers lands east of the main federal ownership boundary. We used three approaches to arrive at an estimate of mass failures that occurred on the non-federal lands (water bodies 1, 10,11, and 12, those areas downstream from the Mt. Idaho bridge). We looked at the mass failure rate from the NPNF data set for basalt geologic and basaltic aquatic landtypes that the NPNF has mapped over the prairie lands. This resulted in estimates of three to seven mass failures for the non-federal area. In addition, as we examined aerial photos of the area for evidence of recent mass failures. Three mass failures were identified that appeared to be about 200 cubic yards in size each. On-the-ground surveys of Cottonwood Creek (DEQ, NPT, USEPA 2000) identified several large debris torrents that had occurred in similar terrain. Based on this combination of information, we chose to ascribe four mass failures in the 200-500 cubic yard size class to water bodies 1, 10, 11, and 12 as shown in Table L-5. Anecdotal evidence and other observations confirm that it is likely that at least this much material moved massively during the 1996 event.

Table L-5. Sediment from road-related mass failures.

Mass Failure Data						
Water Body No.	Water Body Name	Number of Mass Failures (15 yr)	Total Mass Failure Sediment per Water Body	Mass Failure Sediment per Year per Water Body	Routing Coefficient	Routed Mass Failure Sediment
			(t/WB)	(t/WB/yr)		(t/WB/yr)
1 (Est)	Lower SF CWR	1	320	21	0.54	12
10 (Est)	Threemile Creek	2	640	43	0.53	23
11 (Est)	Butcher Creek	1	320	21	0.60	13
12-Non FS* Land (E)	Mid-Lower SF CWR	1	320	21	0.55	12
12-FS** Land	Mid-Lower SF CWR	28	5,715	381	0.55	210
13	Mill Creek	4	2,697	180	0.52	94
14	Lower Johns Creek	1	122	8	0.51	4
22	Middle SF CWR	4	340	23	0.54	12
37	Lower Red River	2	737	49	0.61	30
55	Upper American R.	3	423	28	0.56	16
77	Silver Creek	2	170	11	0.56	6
78	Peasley Creek	1	122	8	0.62	5
79	Cougar Creek	3	219	15	0.64	9
80	Meadow Creek	2	180	12	0.52	6
	Total					451

*Non FS = not federally managed
**FS = federally managed

The data show that the largest sediment rate from mass failures is in the mid-lower SF CWR, which is also the largest water body in the subbasin. This is consistent with other data about the location of rain-on-snow induced mass failures occurring at lower elevations (McClelland et al. 1997), such as the location of the mid-lower SF CWR. At higher elevations, the precipitation occurs as snow and thus does not result in over saturated soil mantle conditions. While the estimated total sediment delivery from mass failures is less than that for NEZSED/forestry, state and county roads, and in-stream erosion, it is significant in relation to them and constitutes a major portion of the total sediment budget for the land above Harpster.

County Roads Outside the Federal Boundary (WEPP Roads Model)

The major sources of sediment from private lands are agriculture, grazing, and roads. The two other sources of sediment from non-federal lands, gravel from State Highway 14 and mass failures, have been accounted for above. To be able to quantify the sediment coming from the graveled county roads, we initiated a project, with funding from USEPA, with the Agricultural and Biological Engineering Department at the University of Idaho to develop methods to apply the WEPP roads model (Elliot et al. 1995, Flanagan and Livingston 1995) to unpaved public roads on the non-federal lands. Details of the results of the project are available at the DEQ Lewiston Regional Office in the final project report (Boll et al. 2002). A summary of the results is in Table L-6.

The WEPP road model is a process-based model of surface erosion originally developed for agriculture. A roads module was later added and is being developed by the USFS as a method of more detailed analysis beyond the NEZSED approach (Elliot et al. 1995). The model requires detailed input of climate, soils, road surface, local topography, road drain spacing, road design, road surface condition, and relationship of the road to surface drainage systems. The amount of detail required is often difficult to attain at the large scale needed for a subbasin assessment.

We contracted with the University of Idaho to develop a GPS capability to record needed model inputs and a GIS interface to manipulate the GPS data to provide the inputs for the WEPP road model. Essentially, the system was set up to run over and over again for every road segment defined by every high point in a road and every low point and/or cross drain. The data in Table L-6 show numbers for sediment detachment and sediment delivery. The model calculates sediment produced (detachment) from the road prism by precipitation events (a 30-year climate generator was used), then routes the sediment across the landscape to the surface water system (delivery). If a cross drain or road ditch empties directly into a surface water system channel, then delivery is 100%. Otherwise, the sediment carrying water is “buffered” such that percent sediment delivery is reduced by the landscape conditions before the water reaches a stream channel.

Table L-6. Sediment predicted by the WEPP road model for county roads in the SF CWR Subbasin.

WEPP Data									
Water Body No.	Water Body Name	Total Detached Sediment	Total Delivered Sediment	Weighted Detached Sediment	Weighted Delivered Sediment	Est. Total Detached Sediment	Est. Total Delivered Sediment	Routing Coefficient	Est. Total Routed Sediment
		Sampled	Sampled	Sampled	Sampled	Calculated	Calculated	Calculated	Calculated
		(t/WB/yr)	(t/WB/yr)	(t/mi/yr)	(t/mi/yr)	(t/WB/yr)	(t/WB/yr)		(t/WB/yr)
1	Lower SF CWR	36	16	4	2	253	110	0.54	60
10	Threemile Creek	79	51	6	4	393	253	0.53	134
11	Butcher Creek	124	59	12	6	390	185	0.60	111
12	Mid-Lower SF CWR	103	40	10	4	701	271	0.55	149
81	Sally Ann Creek	57	21	8	3	177	64	0.66	42
82	Rabbit Creek	23	12	4	2	56	29	0.67	20
	Total								516

We collected data of a sample of the roads in each of the water bodies to the west of the federal lands. We calculated a weighted average of sediment per mile of road sampled in a water body and extrapolated that sediment erosion rate to all the unpaved county roads in our GIS coverage of the water body. Since WEPP predicts sediment delivery to a stream channel, once again there is need to route the sediment through the hydrologic system of the water body. As with all the other sediment data for this sediment budget, we routed the sediment using the Roehl (1962) routing coefficient.

The estimated sediment produced by county roads is of the same magnitude as estimated sediment from NEZSED, in-stream erosion, the state highway, and mass failures. Given the error of the estimates, it would be difficult to argue that any one of these is more or less important than the other in the overall sediment budget, or that any one of them is not important to reducing the sediment load in the SF CWR Subbasin

Agriculture and Grazing Land Surface Erosion (RUSLE)

The sediment production situation for the agricultural and grazing lands on the lands to the west of the NPNF boundary within the SF CWR Subbasin is quite different from the sources discussed above. The Cottonwood Creek TMDL (DEQ, NPT, USEPA 2000) identifies a sediment load from Cottonwood Creek alone approximately five times greater than all the sediment discussed above from the rest of the subbasin. The Threemile Creek watershed encompasses many of the same land use practices and produces a proportionate amount of sediment. Since we have to account for all the sediment as it leaves the subbasin at Kooskia, we have included sediment data from the Cottonwood Creek TMDL, as well as developed some of our own for comparison purposes.

We were fortunate that at the time when we were starting work on this TMDL, the same group at the University of Idaho who did the WEPP work for us was completing a RUSLE model (Renard et al. 1997) of the Clearwater Basin (Boll and Brooks 2002). They are currently running the model in a GIS mode (Engel 1999), which requires inputs of digital coverages of the various parameters.

They reran the model in a more detailed manner for our areas of interest, specifically updating the land use map of Cottonwood Creek, Threemile Creek, Butcher Creek, Sally Ann Creek, and Rabbit Creek, as well as using the SSURGO soils data set instead of the STATSGO soils data set. The original land use map had been developed from satellite imagery and ground-truthed in the Lawyers Creek watershed. We found that in the SF CWR Subbasin, it showed far too much cropland and too little hay and grassland. We adjusted these data such that only the Threemile Creek and Cottonwood Creek watershed show any significant annual cropland, which is consistent with the cropping pattern in the region.

Table L-7 shows the results of the RUSLE model of sediment production in all the water bodies to the west of the federal boundary, including the Cottonwood Creek water bodies (upper and lower Cottonwood Creek, upper and lower Red Rock Creek, Stockney Creek, Shebang Creek, South Fork Cottonwood Creek, and Long Haul Creek). As with the

NEZSED data, we subtracted out an estimate of background sediment to produce an estimate of human-caused sediment, then routed it using the routing coefficient. We used a value of 30 tons/square mile as the estimate of the background sedimentation rate. This number was derived in part from the range of background sedimentation rates used in NEZSED for dry forest types on the same landtypes that occur to the west of the NPNF. We also examined RUSLE results from Washington State University where efforts were made to determine a minimal erosion rate under grassland conditions (McCool et al. 2000).

In comparison to the estimated sediment production from other sources in the subbasin, these numbers are an order of magnitude greater. For the croplands, we compared the estimated sediment numbers to those from Washington State University (McCool et al. 2000) and they are what would be expected for croplands in this region. From the total routed human-caused sediment, 10,473 tons/year are from the water bodies being addressed in this TMDL, of which 9,547 tons/year are from the 303(d) listed water bodies. The differences between the estimates of sediment production for Cottonwood Creek using the RUSLE model and the sediment loading estimates in the Cottonwood Creek TMDL are discussed in Appendix M, Sediment Loading Calculations.

Table L-7. RUSLE model sediment predictions from agriculture, grazing and forestry outside the federal ownership boundary in the SF CWR Subbasin.

RUSLE Data							
Water Body No.	Water Body Name	Sediment in Tons per Square Mile	Sediment in Tons per Water Body	Estimated Background	Human-Caused Sediment	Routing Coefficient	Routed Human-Caused Sediment
		(t/mi^2/yr)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)		(t/WB/yr)
1	Lower SF CWR	86	2,638	925	1,713	0.54	925
2	Lower Cottonwood Cr.	494	12,572	794	11,778	0.55	6,478
3	Upper Cottonwood Cr.	599	19,807	995	18,812	0.53	9,970
4	Lower Red Rock Cr.	567	2,633	139	2,493	0.76	1,895
5	Upper Red Rock Cr.	704	25,261	1,101	24,160	0.52	12,563
6	Stockney Cr.	650	19,898	937	18,962	0.54	10,239
7	Shebang Cr.	423	11,691	862	10,830	0.55	5,956
8	SF Cottonwood Cr.	520	10,108	594	9,513	0.58	5,518
9	Long Haul Cr.	479	6,194	413	5,781	0.62	3,584
10	Threemile Cr.	347	11,632	1,007	10,626	0.53	5,632
11	Butcher Cr.	102	1,708	503	1,205	0.60	723
12-Non FS* Land	Mid-Lower SF CWR	55	4,817	694	4,123	0.55	2,268
81-Non FS Land	Sally Ann Cr.	87	1,205	294	911	0.66	601
82-Non FS Land	Rabbit Cr.	96	784	270	514	0.67	344
	Total	5,209	130,947	9,525	121,422		66,698

*Non FS = not federally managed

Sediment Budget

All of the data discussed above are summarized in Table L-8. These summary data are used in the sediment loading calculations discussed in the sediment TMDLs in Chapter 5 of this document. Of interest for the purposes of a TMDL and loading reductions is the difference of nearly two magnitudes between sediment loading from forested water bodies compared to water bodies used primarily for agriculture and grazing. The same data are presented graphically in Figures L-2 and L-3.

Table L-8 and Figures L-2 and L-3 identify those water bodies that appear to be contributing significant amounts of sediment to the main stem SF CWR. For the water bodies above Harpster, the total amount of human-caused sediment being routed through the water bodies ranges from zero for those water bodies in the wilderness to a high of 3,191 tons/year for the lower-mid SF CWR around Harpster (water body no. 12). The next two highest sediment producing water bodies are the next two water bodies upstream from Harpster on the main stem (middle SF CWR (water body no. 22) and the upper-mid SF CWR (water body no. 30)). Aside from these main stem water bodies, the following water bodies upstream from Harpster are producing greater than 100 tons of sediment per year: Mill Creek, middle Red River (which includes Dawson Creek), upper Red River, lower Elk Creek, and Meadow Creek. Water bodies producing between 50 and 100 tons of sediment per year include: lower Red River, Moose Butte Creek, lower American River, East Fork American River, upper American River, Big Elk Creek, and Cougar Creek. Figure L-2 shows the distribution of human-caused sediment by water body.

To account for the varying sizes of the water bodies, another way of looking at sediment production is on a per unit area basis. Apart from the main stem water bodies which produce the most sediment on a per unit area basis, the following water bodies are producing the most sediment: lower Elk Creek, 32 tons per square mile per year (t/mi^2/yr); middle Red River (which includes Dawson Creek), 98.6 t/mi^2/yr; lower Newsome Creek, 87.5 t/mi^2/yr; Big Elk Creek, 6.4 t/mi^2/yr; Little Elk Creek, 6.1 t/mi^2/yr; lower Red River, 5.4 t/mi^2/yr; and Buffalo Gulch, 5.1 t/mi^2/yr. Water bodies in the 3-5 t/mi^2/yr range include Mill Creek, Meadow Creek, Cougar Creek, Peasley Creek, Haysfork Creek, Mule Creek, Bear Creek, middle Newsome Creek, Maurice Creek, lower and upper American River, Siegel Creek, Moose Butte Creek, lower and middle South Fork Red River, and upper Red River. The other 303(d) listed water bodies, Sing Lee Creek, Nugget Creek, and Beaver Creek, are producing in the range of 1 to 3 t/mi^2/yr of human-caused sediment. Figure L-3 shows the distribution of human-caused sediment per unit area.

Table L-8. Summary sediment budget for all assessed nonpoint sources in the SF CWR Subbasin.

Water Body No.*	Area	WEPP and State Highway	NEZSED	RUSLE	Mass Failures	In-stream Erosion	Total Sediment	Background Sediment Rate	Total Background Sediment	Routing Coefficient	Routed Human-Caused Sediment
	(mi^2)	(t/yr/WB)	(t/yr/WB)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/mi^2)	(t/WB/yr)		(t/WB/yr)
1	30.8	72.44		2,637.89	21.33		2,731.67	30.00	924.60	0.54	974.97
2	26.5			12,571.52			12,571.52	30.00	793.50	0.55	6,531.78
3	33.2			19,806.96			19,806.96	30.00	994.80	0.53	10,016.73
4	4.6			2,632.50			2,632.50	30.00	139.20	0.76	1,891.57
5	36.7			25,261.17			25,261.17	30.00	1,100.70	0.52	12,632.50
6	31.2			19,898.12			19,898.12	30.00	936.60	0.54	10,206.73
7	28.7			11,691.41			11,691.41	30.00	861.60	0.55	5,917.66
8	19.8			10,107.69			10,107.69	30.00	594.30	0.58	5,557.88
9	13.8			6,193.82			6,193.82	30.00	413.10	0.62	3,605.64
10	33.6	205.14		11,632.46	42.67	615.75	12,496.02	30.00	1,006.50	0.53	6,104.73
11	16.8	137.24		1,708.16	21.33	211.20	2,077.93	30.00	502.80	0.60	948.35
12 NFS	27.6	177.16		4,816.93	21.33		5,015.42	30.00	693.60	0.55	2,378.55
12 FS	61.0	948.00	2,650.54		381.02		3,979.56	38.22	2,502.85	0.55	812.72
13	36.6		1,050.29		179.82		1,230.11	26.77	971.08	0.52	135.51
14	41.2		1,247.94		8.10		1,256.04	29.40	1,211.61	0.51	22.75
15	16.9		1,207.07				1,207.07	71.68	1,207.05	0.60	0.02
16	7.0		345.93				345.93	49.80	345.59	0.70	0.24
17	15.9		510.02				510.02	31.95	508.97	0.61	0.64

Water Body No.*	Area	WEPP and State Highway	NEZSED	RUSLE	Mass Failures	In-stream Erosion	Total Sediment	Background Sediment Rate	Total Background Sediment	Routing Coefficient	Routed Human-Caused Sediment
	(mi^2)	(t/yr/WB)	(t/yr/WB)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/mi^2)	(t/WB/yr)		(t/WB/yr)
18	13.6		543.73				543.73	40.16	543.73	0.63	0.00
19	6.2		550.76				550.76	88.81	550.64	0.72	0.09
20	3.6		316.43				316.43	88.86	316.36	0.80	0.06
21	8.7		416.83				416.83	48.47	416.83	0.68	0.00
22	29.6	468.00	1,167.08		22.68		1,657.75	36.24	1,072.65	0.54	317.96
23	8.3		256.28				256.28	30.16	251.20	0.68	3.47
24	22.9		476.47				476.47	20.04	458.20	0.57	10.40
25	3.8		119.74				119.74	30.06	114.81	0.79	3.87
26	11.3		313.35				313.35	26.85	303.10	0.65	6.63
27	21.3		998.22				998.22	47.09	998.21	0.58	0.01
28	9.2		262.21				262.21	28.53	262.19	0.67	0.01
29	8.0		151.53				151.53	16.84	135.04	0.69	11.34
30	26.8	472.00	847.55				1,319.55	28.03	751.79	0.55	314.08
31	14.8		417.69				417.69	25.07	370.98	0.62	28.76
32	22.6		460.01				460.01	18.82	425.24	0.57	19.83
33	11.9		269.93				269.93	22.62	266.51	0.64	2.19
34	10.5		286.97				286.97	27.08	280.26	0.66	4.40
35	11.7		226.15				226.15	16.73	195.80	0.64	19.50

Water Body No.*	Area	WEPP and State Highway	NEZSED	RUSLE	Mass Failures	In-stream Erosion	Total Sediment	Background Sediment Rate	Total Background Sediment	Routing Coefficient	Routed Human-Caused Sediment
	(mi^2)	(t/yr/WB)	(t/yr/WB)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/mi^2)	(t/WB/yr)		(t/WB/yr)
36	4.2	148.00	147.47				295.47	25.90	109.31	0.77	143.71
37	16.1		375.79		49.14		424.93	17.41	281.17	0.61	87.13
38	25.1		680.29			210.34	890.63	20.06	502.62	0.56	217.28
39	11.1		261.49			12.00	273.49	17.34	191.91	0.65	52.92
40	4.9		111.80				111.80	17.93	88.23	0.75	17.69
41	4.4		107.84				107.84	18.88	82.13	0.77	19.73
42	10.0		185.86				185.86	17.06	170.06	0.66	10.43
43	7.4		135.89				135.89	17.10	124.16	0.70	8.18
44	11.1		215.15				215.15	17.56	193.15	0.65	14.27
45	30.1		744.99			62.26	807.25	19.74	592.77	0.54	116.23
46	5.2		115.14				115.14	18.11	94.53	0.74	15.30
47	3.7		89.97				89.97	21.49	79.93	0.79	7.93
48	3.9		81.15				81.15	20.78	80.85	0.78	0.23
49	7.1		160.17			2.93	163.10	19.89	141.60	0.70	15.10
50	12.2		266.48			15.49	281.96	17.74	215.88	0.64	42.15
51	9.1		216.56				216.56	21.19	191.96	0.67	16.54
52	11.3		281.16				281.16	17.38	195.69	0.65	55.27
53	9.8		235.13				235.13	22.95	224.70	0.66	6.92

Water Body No.*	Area	WEPP and State Highway	NEZSED	RUSLE	Mass Failures	In-stream Erosion	Total Sediment	Background Sediment Rate	Total Background Sediment	Routing Coefficient	Routed Human-Caused Sediment
	(mi^2)	(t/yr/WB)	(t/yr/WB)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/mi^2)	(t/WB/yr)		(t/WB/yr)
54	17.9		413.33				413.33	18.44	328.64	0.60	50.39
55	23.9		621.65		28.19	38.86	688.70	23.54	559.81	0.56	72.81
56	3.6		128.09			123.59	251.68	28.96	105.13	0.79	116.20
57	7.9		190.05			24.53	214.58	18.15	143.91	0.69	48.67
58	13.8		416.10			62.61	478.70	24.45	337.22	0.62	88.23
59	3.3		86.48			3.94	90.41	20.70	69.15	0.80	17.11
60	2.6		62.36				62.36	20.54	52.98	0.84	7.90
61	1.7		38.92				38.92	19.56	33.46	0.91	4.96
62	6.5		188.94			36.04	224.97	24.24	156.82	0.71	48.69
63	6.0		143.43				143.43	19.57	117.05	0.72	19.11
64	2.3		44.24				44.24	16.47	37.39	0.86	5.90
65	5.8		122.06				122.06	19.18	112.01	0.73	7.32
66	1.8		51.81				51.81	24.15	42.99	0.90	7.95
67	8.6		190.11				190.11	17.69	151.61	0.68	26.14
68	9.9		223.54				223.54	21.13	208.98	0.66	9.63
69	5.0		134.79				134.79	23.20	114.38	0.75	15.30
70	4.3		118.57				118.57	25.21	106.88	0.77	9.01
71	6.1		163.02				163.02	25.87	158.09	0.72	3.56

Water Body No.*	Area	WEPP and State Highway	NEZSED	RUSLE	Mass Failures	In-stream Erosion	Total Sediment	Background Sediment Rate	Total Background Sediment	Routing Coefficient	Routed Human-Caused Sediment
	(mi^2)	(t/yr/WB)	(t/yr/WB)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/WB/yr)	(t/mi^2)	(t/WB/yr)		(t/WB/yr)
72	2.8		76.91				76.91	27.70	76.72	0.83	0.15
73	2.4		73.04				73.04	27.12	65.90	0.85	6.08
74	5.2		151.06				151.06	27.77	143.29	0.74	5.79
75	7.8		231.19			0.20	231.39	26.29	205.04	0.69	18.21
76	3.6		107.71				107.71	26.18	95.30	0.79	9.83
77	25.8		638.58		11.34		649.92	24.18	623.03	0.56	14.98
78	14.2		440.00		8.10		448.10	26.61	377.84	0.62	43.58
79	12.1		342.80		14.58		357.38	23.07	278.69	0.64	50.25
80	37.5		1,164.39		11.99	52.58	1,228.95	26.75	1,003.16	0.52	117.59
81-NFS	9.8	52.62		1,205.09		0.60	1,258.31	30.00	294.30	0.66	639.25
81-FS	4.1		128.74				128.74	27.63	113.56	0.66	10.07
82-NFS	9.0	27.76	0.00	783.68		0.30	811.73	30.00	269.70	0.67	365.04
82-FS	0.7		12.90				12.90	17.69	12.03	0.66	0.58
Totals		2,708.36	26,209.85	130,947.41	821.63	1,473.20	162,160.45		33,377.65		71,168.85

*FS = federally managed lands, NFS = not federally managed lands

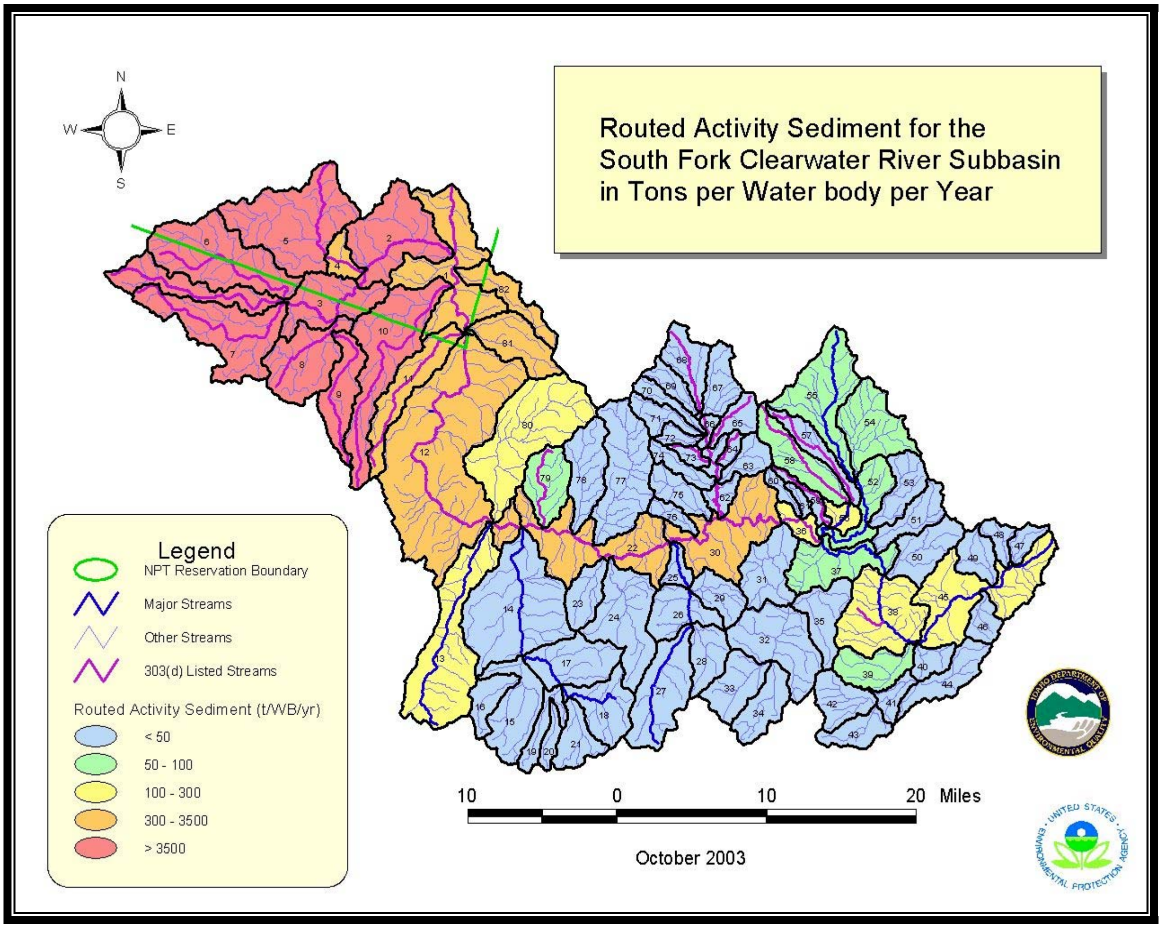

Figure L-2. Annual Sediment Production by Water Body in the SF CWR Subbasin

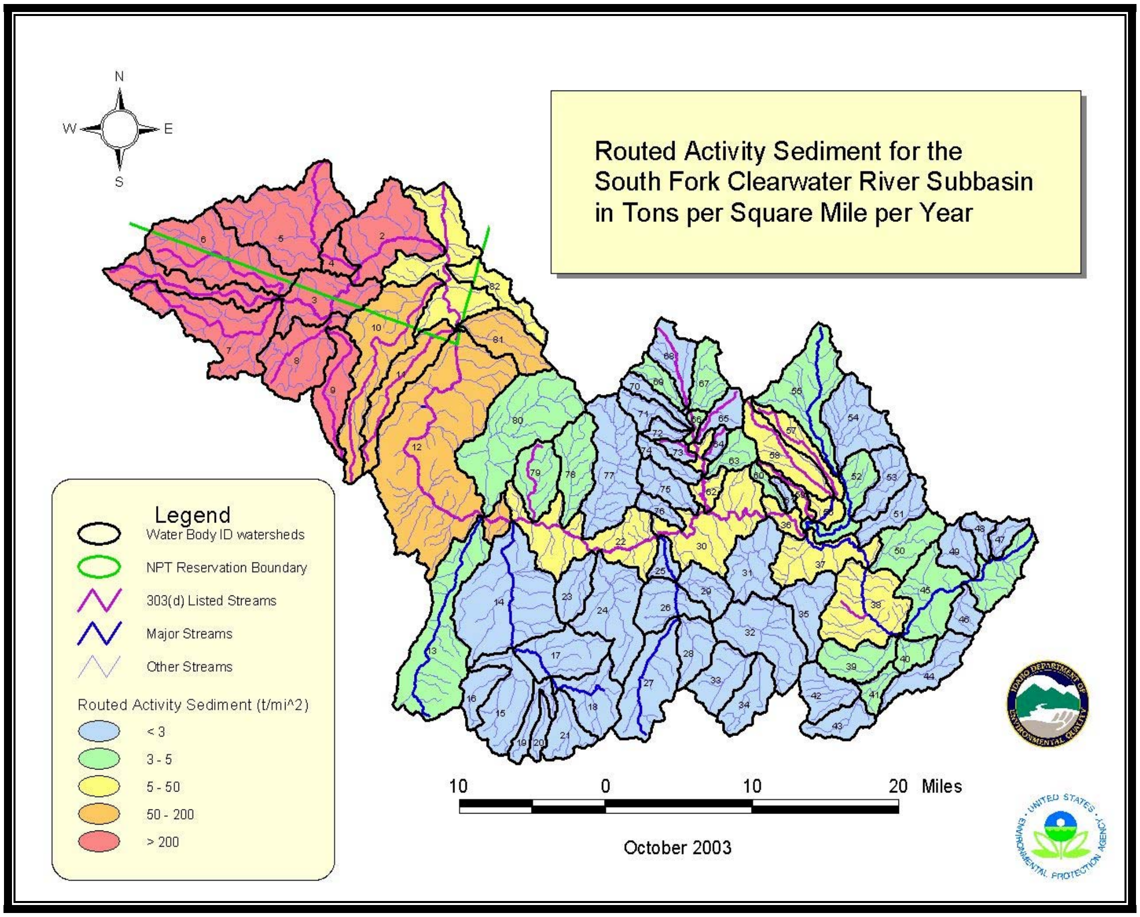

Figure L-3. Annual Sediment Production per Square Mile in the SF CWR Subbasin

Generally, one can conclude from these data that human-caused sediment production is highest in the part of the subbasin where agriculture and grazing dominate (i.e., in the water bodies below Mill Creek. In the water bodies upstream from Mill Creek, the lands along the main stem SF CWR are producing the highest levels of human-caused sediment. Above that, the next level of sediment production comes from the Newsome Creek, American River, and Red River drainages, and Mill, Cougar, Meadow, and Peasley Creeks. These areas include all of the 303(d) listed water bodies, even though the 303(d) listed water bodies themselves are not those producing the highest levels of sediment.

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Attachment L-1: South Fork Clearwater River Subbasin TMDL Stream Bank Erosion Inventory Method

This narrative is intended to document the methodology used to quantify bank erosion in the South Fork Clearwater River (SF CWR) Subbasin. Stream banks were inventoried to quantify bank erosion rates and average annual erosion rates per unit length of stream. These data were used to develop a quantitative sediment budget for the sediment total maximum daily loads.

This inventory followed methods outlined in proceedings from a Natural Resource Conservation Service (NRCS) Channel Evaluation Workshop (1983). Using the direct volume method, sample reaches of selected watersheds within the SF CWR Subbasin were surveyed to determine the magnitude of chronic bank erosion.

Site Selection

Stream reaches with significant eroding bank problems were identified through information from the Nez Perce National Forest (NPNF), U.S. Bureau of Land Management, Idaho County Soil and Water Conservation District, Department of Environmental Quality, Nez Perce Tribe, and other sources. In general, stream reaches identified as having problems tended to be response reaches, Rosgen B and C channel types, with unconsolidated stream bank material. We concluded that, given limited resources and the fact that we were only interested in stream reaches contributing significant amounts of sediment in relation to the whole subbasin, there would be very little value in measuring bank erosion in A type channels. Therefore, we limited our survey to low gradient reaches with known or expected significant bank erosion problems.

Low gradient streams with known bank erosion problems or having characteristics indicating problems were identified using topographic maps, geology maps, NPNF aquatic landtype maps, and aerial photos. The identified reaches were divided into “uniform reaches” for sampling based on available data. Normally a uniform reach was less than 2 miles long. Within each uniform reach, a sample reach of at least 10-20% of the total length of the uniform reach was selected by the field crew. Exact sample reaches were often selected based on access and permission by land owners, although the field crew made every effort to ensure that the sample reach would be representative of the overall uniform reach. Data collected for the sample reach were assumed to be representative of the total uniform reach. In some cases, fieldwork revealed that the uniform reaches were not in fact uniform, and subdivisions were made during the sampling process. Lumping of uniform reaches after initial layout was not allowed.

Field Methods

The NRCS (1983) document outlines field methods used in this inventory. However, some modifications to the field methods were made and are documented here. In addition, we added data types to be collected that could be used to model flow and stream temperature characteristics, as seen on the field forms attached below.

For each sample reach, two levels of data were collected. A set of data was collected for the sample reach in general (see the Sample Reach Summary Form at the end of this document). The whole sample reach, and therefore, the whole uniform reach it represented, is considered to have the characteristics recorded on the Sample Reach Summary Form. Most of the data on this form were collected for other characterization and modeling purposes. The critical measure, recession rate, was determined for the whole sample reach, rather than at each eroding bank.

The field crew was trained by the NRCS in the use of the methodology. Within the sample reach, the field crews surveyed both right and left banks for eroding length and non-eroding length. Within a given sample reach, 100% of both banks were surveyed and documented on the field forms. One crew member walked along each bank, measuring the parameters identified on the Stream Erosion Inventory Worksheet. A new worksheet was started for every new eroding bank encountered. A particular worksheet shows the intervening length between the previous eroding bank and the length of the current eroding bank where measurements were taken. One worksheet was completed for every length of eroding bank, such that for a given sample reach, several (sometimes numerous) worksheets were completed. As noted above, the length of each sample reach was 10-20% of length of the uniform reach identified in the office. The worksheet asks for “Bank Material Classes,” so that eroding banks with significantly different particle size classes over the height of the eroding bank would be recorded separately.

The average annual lateral recession rate is the thickness of soil eroded from a bank surface (perpendicular to the face) in an average year. Recession rates are measured in feet per year. Channel erosion often occurs as “chunk” or “blowout” type erosion. A channel bank may not erode for a period of years when no major runoff events occur. When a major storm does occur, the bank may be cut back tens of feet for short distances. It is necessary to assign recession rates to banks with such processes in mind. When a bank is observed after a flood and ten feet of bank have been eroded, that ten feet must be averaged with the years when no erosion occurred. This will result in a much lower average annual lateral recession rate than a recession rate for one storm. We had the good fortune of surveying the Red River Watershed Management Area where recession rates have been recorded for years so the field crew was able to calibrate its estimates of recession rates against real data. The field crew estimated average annual recession rates by considering evidence of what had happened in the stream over the last 10 years and projecting what might happen in the stream over the next 10 years based on data and statistics of long term flows and extreme events.

The recession rate is critical to completing the calculations, but in some cases it is simply impossible to assess in the field. The indicators used to determine recession rate simply are not present in some cases. The field crew made the determination whether a reasonable estimate of the recession rate could be made in the field. Otherwise, the recession rate was calculated in the office using the correlation methods developed by NRCS and discussed below.

Bank Erosion Calculations

The direct volume method is a procedure which uses on-the-ground measurement of eroding bank surface area, coupled with estimates of recession rate and eroding bank particle size to calculate the total tons of eroding material over a given length of stream. The direct volume method is summarized in the following equation:

$$\frac{(eroding\ area)(lateral\ recession\ rate)(density)}{2000 lbs/ton} = E$$

E = erosion rate in tons/year

The eroding area is in square feet, the lateral recession rate is in feet per year, and density is in pounds per cubic foot of the identified particle size distribution. The total erosion rate for the sample reach is extrapolated to the uniform reach it represents, and erosion rates for all the uniform reaches are summed to develop a total erosion rate for the water body or watershed of interest. Because we selected all the reaches in the subbasin that we had reason to believe were contributing significant sediment through stream bank erosion, we did not attempt to extrapolate our results to the complete stream network in a water body or watershed. We assume that our set of "uniform reaches" is the complete set of reaches that are contributing significant sediment to the sediment budget of the subbasin.

The eroding area is the product of the length of the eroding bank and the eroding bank height. Eroding bank length and bank height were measured while walking along the stream channel. The eroding areas for all the eroding banks within a sample reach were summed and multiplied by the lateral recession rate for the sample reach to get the total volume of eroding bank material.

As noted above in the field procedures, it is not always possible to determine the lateral recession rate in the field. The NRCS method uses the correlation between the "total" of "Rated Factors" one through five (see field sheet below) and lateral recession rates from field assessments to develop a relationship for predicting the recession rate when it cannot be determined in the field. We followed this procedure to estimate lateral recession rates for the approximately 10% of sample reaches where recession rates could not be estimated in the field.

Total bank erosion is expressed as an annual average. However, the frequency and magnitude of bank erosion events are a function of stream discharge. Because channel erosion events typically result from above average flow event, the annual average bank erosion value should be considered a long term average.

The following conversion rates were used to convert eroded bank material volume to eroded bank material weight in pounds. When eroding banks had significant differences in texture from top to bottom and the field crew recorded such, the texture volume-weights were calculated separately and summed.

Soil Texture	Volume-Weight (pounds/cubic foot)
Clay	60-70
Silt	75-90
Sand	90-110
Gravel	110-120
Loam	80-100
Sandy loam	90-110
Gravelly loam	110-120
Very gravelly sands/loams	120-130
Cobbles, boulders, etc.	120-130

The question arises in using these data for construction of a sediment budget as to how much of the eroded bank sediment is actually transported through the system and how much is simply re-deposited in bars and flood plains further down the channel but still within the same water body. The degree to which eroded sediment is flushed through a system is dependent on the flow event causing the erosion, as well as channel characteristics. For the purposes of calculating the sediment budget, we used the same routing coefficient (Roehl 1962) for the in-stream erosion data as we used for all the other sediment source data.

Even then, we realized that the methods being applied resulted in huge estimates of sediment production from stream banks dominated by cobbles, such as those in Threemile, Butcher, and lower Newsome Creeks. While it is clear that the recession rates for these low gradient, cobble-dominated streams is high, as these streams meander around under high flow events, it is also clear that our estimates of sediment delivery from one water body to the next using the Roehl (1962) equation was far too high for cobble-dominated bank systems. Only some small proportion of cobble-sized material eroded from banks of meandering streams is actually delivered to the adjacent water body over the 10 to 20 year time frame of this analysis.

For cobble-dominated streams, we applied the concepts discussed in Beechie (2001) and recognized that only eroded material from reaches near the mouth of a given water body would likely be delivered to the adjacent downstream water body. Beechie (2001) shows that annual travel distance for coarse in-stream material is on the order of twenty times the bankfull width of a stream. Since we had collected bankfull width for each uniform reach as part of the data set, we calculated an annual travel distance for each uniform reach having a significant cobble component, and only delivered cobble from those uniform reaches that were within the travel distance from the mouth. Finer in-stream erosion materials were delivered using the Roehl (1962) equation.

STREAM EROSION CONDITION INVENTORY WORKSHEET

Stream Name____________________________________Reach Number______________________
Left or Right Bank (circle)
Average Bank Height_________________Sample Length__________________________________
Non-Eroding Length_________________________Bank Material Classes (see reverse side)__________

RATED FACTORS	RATING
1. BANK EROSION EVIDENCE	
Does not appear to be eroding	0
Erosion evident	1
Surface of bank eroding and top of bank has cracking present	2
Slumps and clumps sloughing off into stream (SIZE)	3
2. BANK STABILITY CONDITION (Ability to withstand erosion from streamflows)	
Very little unprotected bank, no undercut vegetation, **AND/OR** bank materials non-erosive	0
Predominantly bare and unprotected, some rills, moderate undercut vegetation	1
Almost completely bare, unprotected bank, rills, severely undercut vegetation, exposed roots	2
Bare, numerous rills/gullies, very severely undercut vegetation, falling trees and/or fences	3
3. BANK COVER/VEGETATION	
Predominantly covered with perennials **AND/OR** stable rock/bedrock	0
40% or less bare/erodible, **AND/OR** cover is annual and perennials mixed	1
40% to 70% bare/erodible, **AND/OR** cover is mostly annual vegetation	2
Predominantly bare and erodible/no cover	3
4. LATERAL CHANNEL STABILITY	
No evidence of significant lateral movement of channel	0
Active lateral movement of channel	1
5. CHANNEL BOTTOM STABILITY	
Channel in bedrock **OR** not eroding (Stable)	0
Minor channel bed degradation/downcutting	1
Significant evidence of downcutting, active headcuts	2
6. IN-CHANNEL DEPOSITION	
No evidence of recent deposition (includes all sizes of bedload type materials)	0
Mobile material in recent deposition, deposits will probably move down channel in next high flow	1
Deposition is stable **AND/OR** vegetated (more than this growing season) channel is aggrading	-1

TOTAL________

Factors contributing to erosion (concentrated flows, animal access-trampling, grazing impacts to vegetation, fire return flows, roads, bridges, culverts)____

Other notes____

(Over)

Bank Material Classes

(Circle best Choice/s)

Soil Classes

<15% coarse fragments, just use the fine soil class
(15-35%) Gravelly (gr), Cobbley (co), Bouldery (b)
(35-60%) Very gravelly (vgr), very cobbley (vco), very bouldery (vb)
(>60%) Extremely gravelly (exgr) extremely cobbley (exco), extremely bouldery (exbo)

sand – sa
sandy loam – sal
loamy sand – lsa
clayey sand – csa
silt – si
loamy silt – lsi
silt loam – sil
clayey silt – csi
loam – l
clay – c
loamy clay – lc
sandy clay – sac
silty clay – sic

Notes____

SAMPLE REACH SUMMARY FORM

Stream Name ______________________________
Reach Number______________________________
Hydrological Unit______________________________
GPS Coordinate: Start______________________________
End______________________________
WBID______________________________
Rosgen Channel Type ______________________________
Slope/Gradient______________________________
Bank Full Width______________________________
Bank Full Depth______________________________
Floodplain Width______________________________
Average Wetted Width (ft.)______________________________
Average Wetted Depth (ft.) ______________________________
Average Surface Velocity (ft/sec)______________________________
Sinuosity______________________________
Dominant Particle Size______________________________
Adjacent Land Use______________________________
Canopy Shade Height (ft.)______________________________
Canopy Shade Crown Width (ft.)______________________________
Canopy Offset (from waters edge) (ft.)______________________________
Canopy Density
Topographic Altitude: Rt.________________ & Lft.______________
Mannings "n"______________________________
Recession Rate (Field Estimate)______________________________

Field Crew______________________________

Canopy Density Examples

Open Pine	65%	
Closed Pine	75%	X % Covered
Tight Spruce/Fir	85%	
Dense Emergent Vegetation	90%	

Bed Particle Size

Clay	.001
Silt	.004 to .06 .03 median
Sand	.06 (Fine) to 2mm
Gravel	4mm (Pea Size) to 64mm (tennis Ball size)
Cobble	> 64mm to 250mm (Volleyball size)
Boulder	> 250mm
Bedrock	